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ABSTRACT

A number of studies have been done on the relation between reading disability and complications of pregnancy and birth. The procedures and results of major studies are critically reviewed in this document, with attention given to issues of research design, test use, and statistical methods. Although none of the studies reviewed is free of methodological problems, the weight of the evidence supports the hypothesis that perinatal problems, especially low birth weight, are related to reading disability. Neonatal neurological damage is suggested as the major independent variable for investigators to pursue in the future. Included are an annotated list of references, an extensive table charting the findings of the major studies discussed in the document, and an appendix listing the reading and intelligence tests used in the major studies. (Author/JM)

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PERINATAL EVENTS AS PRECURSORS OF READING DISABILITY

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PERINATAL EVENTS AS PRECURSORS OF READING DISABILITY

Bruce Balow, Rosalyn A. Rubin, and Martha J. Rosen

Scientific discussion of the role that perinatal factors play in the development of neurological, intellectual, and behavioral disorders dates back to the 19th century, but until relatively recently most researchers' attention was focused on the more obvious expressions of brain damage, such as cerebral palsy, epilepsy, and gross mental retardation. Although discussed occasionally in earlier years, the question of a relation between such factors and reading disability has been a major subject of investigation only during the past two decades. In this period, an increasing number of researchers have considered the less severe elements of what Pasamanick and his collaborators have termed "the continuum of reproductive casualty" (Lilienfeld & Pasamanick, 1956). These subtler components are thought to include moderate mental retardation, childhood psychoses, behavior problems, and reading disability.

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Early Studies

The authors of the first major study of the relation between perinatal factors and reading disability, Kawi and Pasamanick (1959), stated in the opening section of their monograph:

> Thus, our hypothesis that there exists an association between maternal and fetal factors with the development of reading disorders in childhood rests on these many clinical impressions and observations encountered in the literature and on previous studies of this problem that indicate that cerebral injury might be implicated in the development of reading disorders in childhood. (p. 15)

In the previous pages they cited two groups of studies as support for their hypothesis.

The first of these are studies giving evidence of or theoretical bases for relations between various perinatal problems and the following variables: poor growth and development, fetal and neonatal abnormality and mortality, epilepsy, mental deficiency, spastic paralysis, congenital diplegia, school problems, nervous disability, congenital defects, cerebral palsy, and personality deviations. Reading is mentioned specifically only in Beskow's (1949) study, a follow up of 273 premature children at 9 to 17 years of age. He found that 25% of them had been referred to a child guidance clinic for school difficulties: 49 for difficulty in following instructions, 16 for pronounced nervous disturbances, and 3 for reading disability.

The last figure yields an incidence of 1.09%, which is remarkable only for its small size.

Secondly, Kawi and Pasamanick cited literature examing the relations between reading and these variables: visual function or disturbance of function, auditory and speech difficulties, physical deficiencies, intelligence, emotional maladjustment, environmental and social factors, sex differences, and (most importantly) neurological defect. It is under this last rubric that they cited two authors who included birth injury in their list of causal factors of reading problems.

Bronner (1921) summarized a 1910 article by McCready, which mentioned intrauterine and delivery problems as causes of reading disability, but she did not go into the role of birth difficulties in causing the special abilities and disabilities with which she was concerned. Kawi and Pasamanick evidently misread her summary of McCready's ideas as representing her own.

Bronner discussed seven cases of special language defect; developmental history was negative in six and unknown in one. In the 46 case histories she discussed, birth problems were mentioned twice. Low birth weight was mentioned in the case of a girl with poor perception of form and form relations, who could read fluently without being able to explain what she had read. A difficult pregnancy, instrumental delivery with head marking, and early marasmus (dietary protein deficiency) were mentioned in the case of a boy who was described as erratic and uncontrollable; any or none of these three factors could have been responsible.

McCready discussed congenital word blindness, basing his arguments on 41 cases available in the literature. He believed that hereditary factors are the principle cause of congenital word blindness, but that it can occur as a result of "defective development, either intrauterine or as the result of injuries received during labor" (p. 281). As Bronner pointed out, he made no attempt to reconcile these ideas with his ideas about the role of heredity. Nevertheless, she described his article as "one of the best...from the standpoint of review and discussion of the literature" (p. 85). McCready did not cite any evidence for the role of intrauterine and delivery factors in causing congenital world blindness, although he did cite seven case histories in which close relatives of the index cases could not read and three cases in which a "neuropathic family history" was present, all in support of heredity as a factor.

Hinshelwood (1917), also cited by Kawi and Pasamanick, suggested that defective development of a portion of the brain (the left angular and supra-marginal gyri) due to hereditary factors is the cause of many cases of congenital word blindness. He referred to "isolated cases" in which disease or birth injury caused congenital word blindness, withouth offering any evidence. He seemed to believe that defective development also operates in these cases.

A Swedish researcher, Malmquist (1958), prepared a monograph on reading disability at about the same time as Kawi and Pasamanick. In an extensive review of the literature, he did not include

perinatal difficulties among the possible causal factors of reading disability previously investigated. In a different section of the monograph, he cited one paper by Eames (1945) as support for his hypothesis that perinatal problems are related to reading difficulty.

Eames investigated a random sample of 100 cases of reading failure. Reading failure was not defined, and he did not state how he located the cases. He found that 85 of the children were full-term babies and 15 were premature babies, defined as birth before term or birth weight no more than 5 1/2 pounds (2,500 g). The source of the birth information is not mentioned.

The premature and full-term groups were "closely parallel" in the proportion of each sex, in median chronological age, and in median IQ score. Neurological lesions, which Eames did not define, were present in 41% of the premature children and in 9% of the full-term children.

One can safely conclude from these studies that prior to the mid-1950's experimental evidence and recorded clinical impressions of the role that perinatal factors can play in causing reading disability were in very short supply. Kawi and Pasamanick seem to have misread Bronner, misconstrued Beskow (by citing the 25% of the group with school problems rather than the 3 cases of reading disability), and, in general, overstated their case. Thus the literature cited by Kawi and Pasamanick, contrary to their interpretation, offers little or no support for the hypothesis that

reading failure is especially related to anomalous events of pregnancy and birth.

The Current Situation

Fifteen years after the study by Kawi and Pasamanick was published, there is no conclusive evidence that some kinds of reading disability are components of the "continuum of reproductive casualty." There are many studies directed toward or touching on the subject, but it is difficult to establish any clear position from them. They were published over a 20-year period in four different countries, using varied reading tests, research designs, and methodologies, and all seem to have defects. Studies indicating that there is an association between perinatal problems and reading disability and those that do not confirm such an association have like methodological problems, ranging from serious to minimal. The most serious problems are contained in the retrospective nature of many of the studies.

Three research methodologies have been used in studies of perinatal factors and later development. They are generally referred to as retrospective, retrospective follow-up, and prospective designs. Each method has its shortcomings, with the most serious problems associated with the retrospective method. This design has been used in seven studies supporting the hypothesis that there is an association between perinatal problems and reading disability and in four studies failing to confirm the hypothesis.

Nevertheless, in spite of methodological shortcomings, and despite a lack of clearly established causal chains leading from perinatal insult to reading difficulty, the weight of the accumulated evidence supports, at minimum, the hypothesis that low birth weight, as well as certain pregnancy and birth complications, is related to impaired reading ability.

Retrospective Studies

Kawi and Pasamanick (1959) compared the hospital birth records of 205 young white males, who read at least 2 years below grade level, with those of the next birth of the same sex, race, maternal age, and hospital, recorded subsequently to each poor reader. There was no control for social class; significantly more poor readers than controls were in the lower socioeconomic half of the population. Most of the retarded readers were 10 to 14 years old when identified for the study.

Kawi and Pasamanick found significantly more premature births (birth weight under 2,500 g) among the poor readers, as well as a significantly higher incidence of pregnancy and birth complications--especially maternal pre-eclampsia, hypertensive disease, and placental abnormalities--among the poor readers. The authors state that the differences in the incidence of such complications were not accounted for by differences in socioeconomic status, maternal age, or number of previous pregnancies.

As the first major study of the relation between perinatal problems and reading disability, this study is historically important, and the findings are intriguing. However, it should be

noted that while differences in certain of the findings were statistically significant, the absolute values for reading-disabled and control children necessitate caution about their practical import. For example, one condition, bleeding prior to the third trimester, occurred during the pregnancies of 10.3% of the mothers of the reading-disabled children and 3.4% of the mothers of the controls. This difference is statistically highly significant, but for practical purposes of prediction or preventive action it is of little value, because the percentages are so low. Even if this pregnancy complication were completely eradicated, no material change in the incidence of reading disability among school children would be effected.

The sample included only boys and only whites, which limits the study's applicability. More telling are the shortcomings inherent in the retrospective design. Typically, the old medical records used for critical items of information in this design are demonstrably incomplete and frequently inaccurate, to the extent that the quality of the data on which any findings are based is in serious question. Moreover, even if the hospital records used in this and similar studies were of unquestioned validity and reliability, a retrospective study yields backward contingency probabilities, rather than forward contingency probabilities (e.g., the probability that a disabled reader was premature or suffered a perinatal insult is a backward contingency, whereas the question of the probability that a premature baby will become a disabled reader is a forward contingency). Backward statements are of limited

predictive value (Gottfried, 1973); the central concern in this review is the latter, or forward, statement.

Kawi and Pasamanick concluded that reading disability should be considered a component of the continuum of reproductive casualty, albeit one that is more subject to environmental influence than others. In view of the methodological problems of their research, a preferable conclusion might be that a new area of investigation was opened up, with no assurance of the ultimate outcome of such investigation. Such comments do not deny the importance of this study and other retrospective studies in contributing to the formation of hypotheses about the relation between perinatal stress and reading disability. It was on the basis of findings and conclusions from retrospective studies, however weak they now appear, that well-controlled, prospective studies could be planned.

As part of his study of factors in reading disability, Malmquist (1958) investigated the obstetrical background of 399 Swedish first-graders, randomly chosen from two school districts. Reading disability was defined as performance at least one standard deviation below the mean on five reading tests designed by Malmquist, with reliability and validity experimentally established. Birth histories were obtained from the children's parents and then checked against maternity hospital and midwife records. Again, the problems inherent in the retrospective method are present, with the added problem that parental memory is often unreliable insofar as child growth factors and significant life events are concerned (Wenar, 1963).

There was no significant difference among the poor, medium, and good readers in the incidence of difficult births. Prematurity occurred significantly more often among poor readers, and significantly more poor readers weighed under 2,500 g at birth. Birth weight under 2,500 g is frequently used as the definition of prematurity; one can infer from Malmquist's separate mentions of prematurity and low birth weight that his definition of prematurity was in terms of length of gestation. On average, poor readers weighed less at birth than other children, although not significantly less.

Using a Swedish version of the Terman-Merrill Intelligence Scale, Malmquist found significant differences in intelligence among the groups, with the poor readers having the lowest mean IQ. There were also significant differences between the poor readers and the other children on personality factors of nervousness, self-confidence, persistence, concentration, and dominance-submissiveness, as measured by rating scales. There was a significant correlation between reading ability and social group.

Versacci (1966) examined the relation between birth information data and reading achievement among 200 5th-grade students, 100 each high- and low-achieving readers. The California Test of Mental Maturity and the Iowa Test of Basic Skills were used to determine the children's IQ and reading achievement; birth information was taken from hospital records. The subjects were randomly drawn from among high- and low-achieving students who met three criteria: local birth, complete test scores available, and

parental cooperation received. No control procedures were used to match the two groups; no information on the subjects' sex, race, or socioeconomic status is included.

The two groups of readers were differentiated by three factors: a) prematurity, as defined by length of gestation and birth weight under 2,500 g; b) the frequency of complications of pregnancy; and c) the number of previous pregnancies and the total number of complications experienced by the mothers. The two groups were not differentiated by maternal age, length of labor, birth weight alone, prematurity as defined by length of gestation and birth weight over 2,500 g, delivery complications or operative procedures, frequency of previous pregnancies with miscarriages, or number of previous pregnancies with stillbirths.

Doehring (1968) studied the extent of problems other than in reading, including the incidence of perinatal problems, among 10-to-14-year-old boys who scored at least 2 years below age level on the Wide Range Achievement Test. He compared 39 such boys, all of whom had an IQ of at least 90 and did not have any psychiatric or sensory disorder, with 39 normal readers, matched for age, sex, and IQ.

There were no significant differences between the two groups in complications of pregnancy, type of delivery, or general condition at birth. However, among the retarded readers there were somewhat higher incidences of prematurity, short and long labors (under 3 and over 24 hours), and low birth weight. The birth information was collected in interviews with the children's mothers and is thus of uncertain reliability.

Galante, Flye, and Stephens (1972) followed 71 children attending a suburban public school from kindergarten through 6th grade, in order to determine what early factors can act as predictors of school achievement. Among their many sources of data were pre-kindergarten interviews with the children's parents and a check of family physician and birth hospital records, done while the children were in kindergarten.

Three groups of children were defined by comparing reading achievement and reading expectancy information derived from achievement and intelligence tests. Reading expectancy level was established by mental age from the IQ test. Children in Group A, underachievers, were divided into Subgroup A_1, those reading 2 or more years below their potential, and Subgroup A_2, those reading at grade level but underachieving by definition. The other two groups were Group B, those children reading at their expected level, and Group C, those children reading at least 1/2 year above the expected level.

Four of the seven members of Subgroup A_1 had an unusual birth history, including such factors as precipitous delivery, short labor (under 5 hours), Rh factor replacement transfusion, and prematurity with first trimester bleeding. In Group A as a whole, 9 of 22 children had an unusual birth history (40.9%), compared to 7 of 49 children (14.3%) in Groups B and C combined, a significant difference.

The authors stated that no single causative factor differentiated the groups, but different combinations of minor factors were

evident in all seven children of Subgroup A_1. Early test scores found to be predictive of underachievement in later grades reflected various factors which they judged could be compensated for when occuring singly but which are too overwhelming to be overcome when occuring in combination. These factors included an unusual birth history, eye muscle imbalance, abnormal EEG, and other signs of neurological involvement.

In considering the differences between normal readers and poor readers with adequate and inadequate visual perception, Black (1972) compared the incidence of birth abnormalities in three groups of 30 subjects each, matched on age, grade, and WISC Full-Scale IQ. Reading retardation was measured via the Wide Range Achievement Test and visual perception by the Frostig Developmental Test of Visual Perception with a Perceptual Quotient of 85 chosen as the cut-off point between adequate and inadequate perception. The mean reading level of the retarded readers was 1.12 years below grade placement, while it was .41 years above grade level for the normal readers.

The incidence of birth abnormalities was significantly higher among high-perceiving retarded readers (8 cases) and low-perceiving retarded readers (16 cases) than among normal readers (2 cases). The lack of information about the age and sex of the subjects and about the source of the birth information reduces the usefulness of this study.

The obstetrical background of 125 disadvantaged children with serious and prolonged learning and behavior problems was compared

with that of 125 control children by Kappelman, Rosenstein, and Ganter (1972). The children ranged in age from 5 through 14 years; most were 6 through 10. Members of the two groups were individually matched for age, sex, neighborhood, birth order, and race. The learning-problem children had been referred to a remedial clinic by their teachers, while the controls were randomly selected from the same school area. Birth information was obtained from a questionnaire filled out by the children's mothers and from the records of all medical facilities caring for the mothers and children.

It was found that the clinic group had a significantly higher incidence of breech extraction, low birth weight, and pre-eclampsia. They also had a higher incidence of antepartum bleeding, but this difference was not significant. Overall, 21.6% of the clinic children and 13.6% of the control children had some birth process problem.

Among the clinic children, there were more cases of neonatal respiratory distress, a finding that was influenced by the birth weight differences. When all possible documented neonatal problems were combined, 11.2% of the clinic children and 8.8% of the control children had one or more problems, reflecting no real difference in the incidence of documented neonatal problems.

There was a marked difference in the distribution of IQ scores, with the clinic children having a lower overall distribution than the controls. Both group and individual tests were used to determine the subjects' IQ's. Children registering at the

clinic were customarily tested with the WISC, so it is possible that their IQ's were all derived from that test, while IQ's for the controls were based on group tests. Whether test use was dichotomized in this manner or whether both kinds of test were used within each group is less important than the fact that IQ's derived from individual tests are not properly comparable with IQ's from group tests.

Among the clinic children, there were more large families, lower parental educational achievement, and a higher incidence of deviation from the traditional two-parent family structure. The authors suggest that the social disruption inherent in these family arrangements may have interacted significantly with the perinatal complications, aggravating their effect.

Use of the retrospective method of data collection is especially questionable in this study, because parental responses to questions about their children's development may be particularly inaccurate in disrupted families and in families where some sort of clinical referral (e.g., to a remedial clinic) has occurred prior to the interview. In the first case, distortion may occur because parental records are less likely to be maintained amid the sort of living stresses which may already have affected the amount of attention paid to children's development. In the latter case, the stimuli toward recollection of life events with potentially negative outcomes is likely to be greater among clinical clients than among unselected parents.

In and of itself, the low socioeconomic status of the clinic children and their families may have been irrelevant to the accuracy of parental recall. Wenar states that there is no evidence that socioeconomic status is related to overall reliability of recall, although it may affect the type of mistakes that are made. Middle-class mothers are more likely than lower-class mothers to distort their recollections "in the direction of bringing the child in line with cultural norms and ideals" (p. 507).

Four studies using retrospective designs failed to find a link between perinatal problems and reading disability. Richardson (1958) studied predisposing factors to reading success or failure among children from three Australian public schools. A total of 97 pairs of good and poor readers, matched for age, IQ, sex, and nationality, were chosen from pupils in grades 3 through 5. Each poor reader scored at least 18 months below his age group on a reading test, and each good reader scored at or above the average for his age and at least two years above his partner. Birth information was gathered in interviews with the parents. There were no differences in the two groups in the incidence of abnormal pregnancies or births.

Besides the problems of the retrospective method of data collection, this study is handicapped by the evident lack of control for socioeconomic status, a variable known to be of considerable importance to school achievement and to medical care. The schools from which subjects were drawn were in three different neighborhoods, one described as having a low socioeconomic level,

one having more professional and wealthy families, and one described as a middle income area. Neighborhood of residence or school is not listed as one of the variables on which subjects were matched.

Lyle (1970) used a multiple regression technique to compare a retarded reading group, composed of 54 middle-class, white, Australian, 6-through-12-year-old boys, with IQ scores of at least 90 and without sensory deficit, with 54 normal readers, matched for age, sex, class room, time of year of testing, socioeconomic status, race, family size, and birth order. Schonell's Graded Word Reading Test was used to assess reading achievement. The mean reading age difference between the two groups was 2 years.

Information on antenatal, perinatal, and developmental variables was obtained from the boys' mothers, using an open-ended questionnaire. Lyle checked the reliability of maternal recall indirectly by correlating the details recalled with the lapse of time. No significant correlation between the details recalled and the children's chronological age was found. Possible maternal distortions of fact were checked by comparing maternal estimates and hospital records of birth weight, chosen for checking because it is one of the few precise items in hospital records. Lyle concluded that maternal estimates of birth weight were distorted only minimally and equally so among mothers of retarded and normal readers.

However, in a review of five major studies of the reliability of mothers' developmental histories, Wenar (1963) pointed out that

there is evidence that maternal health during pregnancy, duration of labor, use of instruments, delivery injuries of the mother, and neonatal difficulties are all unreliably recalled by mothers. Besides the evidence that distortion often occurs in the direction of bringing the child into conformity with cultural norms and ideals, it has been shown that situational variables, such as the sex of the interviewer, affect maternal recall.

In an earlier factor analytic study, Lyle had extracted two factors related to reading difficulties: F_1, freedom from perceptual and perceptual-motor difficulties, and F_2, formal learning difficulties. In the 1970 investigation, a negative correlation with F_1 indicated a positive association with distortion in reading and writing, while with F_2 a positive correlation indicated such problems. Lyle also investigated significant predictors of a third criterion, R/N, membership in the retarded or normal group.

Symptoms of brain injury at birth were significantly correlated with both F_1 and F_2 ($r = -.267$ and $+.263$, respectively); birth weight was significantly correlated with F_1 only ($r = -.259$). Variables for which no significant correlations were found included toxemia, complications in utero, birth complications, and long and short labors. Developmental variables significantly correlated with the criteria included early speech defects and possible epileptiform symptoms (F_2 and R/N only).

Three speech variables (early speech defects, speech delay at 6 months, and speech delay at 2 years) together correlated

significantly with all three criteria (10%, 9%, and 20% of the variance of F_1, F_2, and R/N respectively, explained). As a group the birth variables correlated significantly with early speech defects ($r = +.403$, 16.24% of the variance explained). Only one birth variable, short labor, was by itself significantly correlated with early speech defects.

Lyle hypothesized that there is a generalized lag in verbal learning among retarded readers, dating from learning to speak and extending to learning to read. He stated that his study substantiates Kawi's and Pasamanick's findings only to a limited extent. In his study high birth weight correlated with reading and writing distortion; only seven of the subjects weighed under 6 pounds (2,720 g) at birth, and six of them were controls. It is important to keep in mind that this study has problems with both the data collection methods and the data analysis methods; the number of subjects may have been too small for the statistical techniques used.

Hunter and Johnson (1971) compared the perinatal histories of 20 8-through-11-year-old boys referred to a remedial reading clinic with those of 20 controls, matched for age, sex, grade, race, intellectual level, and socioeconomic status. Birth information was supplied by the subjects' parents, and the Wide Range Achievement Test was used to determine reading achievement. There were no significant group differences in birth weight, prematurity, or breathing problems at birth. In addition to the retrospective design, this study's validity is undercut by the very small sample size.

A study of reading disability in twins by Bakwin (1973) showed no significant birth weight differences when reading-disabled and normal children were compared by zygosity and sex. His subjects were 674 children, from 338 pairs of like-sex, middle-class twins, 97 of whom had a history of reading disability. The incidence of reading disability was 14.0% in monozygotic twins and 14.9% in dizygotic twins, not a particularly large percentage when contrasted with unselected children. The subjects ranged in age from 8 to 18 years.

Retrospective Follow-Up Studies

The retrospective follow-up design involves identifying groups of children who suffered from certain perinatal problems and then testing the skills of these problem children and a control group. Although this method gives forward contingency probabilities, it, like the retrospective method, uses medical records written for purposes of treatment, which are often inaccurate, incomplete, and, at times, unreadable. Three studies used this method to examine the relation between perinatal problems and reading disability; two found, and one failed to find, a link between the two.

As part of a study of the development of cognitive organization and ego function, Caplan, Bibace, and Rabinovitch (1963) administered the Durrell Analysis of Reading Difficulty, among other tests, to 50 male premature children and 50 full-term control children, matched for sex, birthdate, race, and, roughly, for socioeconomic status. Prematurity was defined as gestation at least 1 lunar month short of full-term and birth weight between

1,500 and 2,250 g. Two age groups of subjects were studied, 7-to-8-year-old children and 11-to-12-year-old children.

There was no significant difference in reading test performance between the younger prematures and their controls. Among the older children, the controls' scores were significantly better than those of the prematures. This age difference is consistent with the study's other findings; the 11-to-12-year-old prematures' performance was significantly poorer than that of their controls on the WISC, the Bender-Gestalt, and the Lincoln-Oseretsky Test of Motor Development, but the younger prematures differed significantly from their controls only on the Lincoln-Oseretsky.

The authors concluded that premature children have a greater incidence of cognitive disorders than full-term children, a difference which is marked in older children. They do not discuss why such an age difference might exist, although they do put forward the suggestion that their results may be due to their tests' greater accuracy with older children, an idea which is susceptible to challenge.

Jordan (1964) studied classroom learning in a high-risk population of 62 children, averaging 12 years in age, whose hospital birth records listed one or more of seven pregnancy and birth complications. These complications included problems of pregnancy, of parturition, of the puerperium, of presentation, of the umbilical cord, toxemias, and miscellaneous operative procedures.

The experimental subjects were compared with a control group formed from the first children born with no complications after each high-risk birth. Evidently matching was done on the basis of age, birth hospital, and sex. The author used eight tests of intellectual functioning and five academic achievement tests, including the Gates Basic Reading Tests and the Stroud-Hieronymous Primary Reading Profiles. Exactly how many children took each test is not stated.

Test results were dichotomized for each child into categories of adequacy and inadequacy. Significantly more children from the experimental group demonstrated learning problems and reading problems.

Methodological considerations reduce the value of these findings. Without knowledge of the children's racial, socio-economic, and academic background, one cannot be sure that the two groups were comparable, even though the controlled variables included birth hospital. The experimental group exhibited significantly more mental retardation than the control group; the effect of this factor on reading performance is almost invariably negative, and must be so considered here, in the absence of evidence that the mentally retarded children were excluded from the sample when reading skills were tested. Because comparability from one IQ test to another and across achievement tests is quite limited, the lack of clarity about test-use is a serious problem.

Uddenberg (1955) located 62 10-year-old former prematures (birth weight under 2,500 g) and matched them with a group of

full-term children for age, sex, birth hospital, social class, and, roughly, for birth order. He compared the performance of the two groups on the Terman-Merrill reading test. There was no difference between the two groups in the number of subjects failing to reach a criterion score, but significantly more prematures than controls achieved only a "poor pass," defined by Uddenberg as reading poorly and without fluency. Such difficulties were considered by him to be due to perceptual difficulties.

Prospective Studies

The final group of studies discussed here used a prospective methodology. Unlike other methods, this design uses data collected specifically for research purposes, which are therefore clearer, more accurate, more specific to the research questions of interest and more detailed than records written for service-related reasons. The major problems with prospective designs are loss of subjects and differential attrition rates in the experimental and control groups. Three of these studies use data from the Collaborative Project on Cerebral Palsy, Mental Retardation, and Other Neurological and Sensory Disorders of Infancy and Childhood (Berendes, 1966).

Douglas studied extensively a group of slightly over 700 British legitimate, singleton, premature children (birth weight no more than 5 1/2 pounds or 2,500 g) who were born in the first week of March, 1946 (Douglas, 1956, 1960). Controls for 675 children were chosen from all full-term, legitimate, singleton children born in the same week and matched for sex, birth order, maternal

age, social group, degree of crowding in the home, and, where possible, area of residence. When they were 8 years old, 408 pairs were tested; at age 11 years, 355 pairs were tested. Mentally deficient and educationally subnormal children were excluded from testing.

In the earlier round of testing, reading, vocabulary, and picture intelligence scores for each child were derived from tests involving the ability to read and understand a list of words of graded difficulty and to appreciate the relations shown in a series of picture strips. The prematures' scores were lower on all three tests. Handicap scores for the prematures were derived using the following formula:

$$\frac{\text{Control Mean Score} - \text{Premature Mean Score}}{\text{Control mean score}}$$

that is, the proportion of the difference between the mean scores of the controls and prematures to the control children's mean score.

The handicap of all prematures for reading was -17.5. Prematures with uneventful pregnancy histories had a handicap of -24.4; prematures from pregnancies with a history of toxemia or bleeding had a handicap of -13.95. Thus, prematures from uneventful pregnancies appear to be more handicapped than prematures from pregnancies with problems. When the size of the mother is also considered, it becomes apparent that the most handicapped prematures are those whose prematurity is explained by neither obstetric difficulty nor the small size of their mothers. However, the

prematures who had histories of obstetric difficulty or small mothers also had a slight but significant handicap in reading.

When Douglas tested his subjects at age 11 years, he used mixed verbal and non-verbal intelligence tests and tests of reading, vocabulary, and arithmetic. Premature children's reading scores were lower than those of control children; Douglas describes the difference as "highly significant" and comments that the prematures appeared more handicapped at age 11 years than they did at age 8 years. However, within similar ranges of mental test scores, the premature children were not at any substantial disadvantage.

In this round of testing Douglas examined the children's familial, social, and educational background. He found that the fathers of prematures were more likely to move to less favorable occupations and were more often unemployed. Both parents of prematures came from manual workers' families more frequently than parents of controls, and fewer stayed in school after age 15 years or otherwise continued their education. Health visitors considered that mothers of prematures showed poorer standards of care and management, and teachers felt that they showed less interest in their children's school progress.

The matched pairs of prematures and full-term children were divided into groups according to whether the prematures' backgrounds were a) superior to, b) equivalent to, or c) inferior to those of the controls. The prematures' scores were consistently better than those of the controls when their backgrounds were

favorably assessed (a), consistently worse than the controls when they were unfavorably assessed (c), and still slightly lower when their backgrounds were similar to those of the controls (b). Although Douglas concluded that it was the poorer home environments of the premature subjects that caused their handicapping, these within-group comparisons suggest that birth weight had an independent effect on later intellectual functioning.

Corah and his collaborators (Corah, Anthony, Painter, Stern, & Thurston, 1965) compared the functioning of 101 7-year-old children who had been anoxic at birth with that of 134 nonanoxic children, born during the same period. Although no attempt was made to match the two groups, relevant variables, including socioeconomic status, sex, age, and school grade, were controlled by statistical manipulation. The tests administered to the children included the Gilmore Oral Reading Test, Form A.

The anoxic group performed somewhat less well on the reading test. Differences in the comprehension and reading rate scores were not significant; differences in the accuracy scores approached significance at the .05 level (two-tailed).

The anoxic group was broken down into subgroups by type (prenatal, postnatal, or perinatal) and severity (good, uncertain, or guarded prognosis) of anoxia. The two sets of subgroups were related in that prenatal anoxics had the lowest mean prognostic score and perinatal anoxics the highest. It was found that those children suffering postnatal anoxia had accuracy and reading rate scores significantly lower than those of the normal children. When

these data were further analyzed, it appeared that anoxics with a good prognosis at birth had the lowest accuracy scores, and anoxics of uncertain prognosis had lower reading rate scores.

These findings are difficult to evaluate. The authors interpret them as suggesting that some deficit in reading ability can occur as a result of anoxia at birth.

The academic performance at three different ages of 53 premature and 53 full-term children was compared by De Hirsch, Jansky, and Langford (1966). The premature children (birth weight no more than 2,500 g) were roughly matched with the control children for age, race, sex, and maternal employment. They were not matched for IQ; significantly more prematures had IQ scores in the 84-94 range (26% vs. 8%), and significantly fewer had IQ scores in the 113-116 range (9% vs. 25%) as measured by the Stanford-Binet Scale.

The two groups were tested during kindergarten and at the end of first and second grades. At the end of first grade, the tests included the Gray Oral Reading Test and the Gates Primary Sentence Reading and Paragraph Reading Tests. At the end of second grade, the children took the Gates Advanced Primary Reading Tests.

In both first and second grades significantly fewer prematures than controls scored at or above the "critical score level," defined as that level of performance which yielded the "best differentiation" between the groups. In first grade, 34% of the prematures and 57% of the controls attained the critical score level ($p \leq .05$), and in the second grade 47% of the prematures and

79% of the controls attained the critical score level ($p \leq .01$). As in some other studies, the data suggest that prematures with a birth weight under 1,500 g are more handicapped than those with birth weights of 1,500-2,500 g, but this is a tentive finding in this study. The authors conclude that low birth weight children "have to be regarded as an academic 'high risk' group" (p. 626), a conclusion suggested by the findings of most other studies on the topic.

Information on reading ability was included in two Baltimore studies of the development of premature children (Wiener, Rider, Oppel, & Harper, 1968; Wiener, 1968). In the first study (Wiener et al., 1968), which considered the children's status at 8 to 10 years of age, 417 premature children (birth weight 2,500 g or less) were matched with 415 full-term control children for race, birth season, maternal parity, hospital of birth, and socioeconomic status. The Wide Range Achievement Test (WRAT) was used to assess reading achievement.

The control children's performance on the WRAT was significantly better than that of the premature children. However, when an analysis of covariance was used to control the effect of differences in neurological status (the premature children exhibited more neurological abnormalities on 15 of 19 indicators), differences on the reading test were no longer significant. The authors concluded that low birth weight may be associated with psychological impairment largely to the extent that there is neurological disturbance accompanying the prematurity.

Wiener (1968) studied the academic achievement of the same children at age 12 to 13 years. He compared 419 premature children and 429 controls, using their most recently administered school reading tests.

A very low correlation of 0.14, significant at the .001 level, was found to exist between birth weight and reading/grade, defined as the child's reading grade score divided by his actual grade placement. Among both the white and non-white members of the sample, reading/grade and reading/age were significantly different in different birth weight groups (under 2,000 g, 2,000-2,500 g, and over 2,500 g). The prematures' deficit in reading achievement remained after the effects of an index of neurological damage were partialled out; however the low magnitude of the correlation raises doubts about the value of these findings.

In a sidelight to these studies, Wiener (1970) examined the relation between birth weight, length of gestation, and intellectual development at 8 to 10 years among these children. There was no significant relation between gestation period and impairment on any measure among the low birth weight group, but among the 405 control children (birth weight over 2,500 g), those with longer gestation periods had significantly higher WRAT reading scores. Similar differences existed for WISC IQ, Bender-Gestalt performance, assessment of speech maturity, and WRAT spelling score. Race, birth weight, and socioeconomic variables were controlled in these comparisons. Gestational age was based on maternal reports, which may be highly unreliable, although Wenar (1963) states that it is

generally recalled reliably. Thus, although gestational age has heuristic value in planning research, its exact relation to cognitive development is still in doubt.

In a study of a common problem of prematurity, elevated blood tyrosine, Menkes, Welcher, Levi, Dallas, and Gretsky (1972) offered some data about WRAT scores of low birth weight children. Their subjects were 62 7-to-8-year-old children who had weighed under 2,500 g at birth. When grouped by birth weight (under 1,500 g, 1,500-2,000 g, and over 2,000 g), there was an increase in reading score from the smallest to the largest. However, the sample was too small and the variance too large for the differences to reach statistical significance. No information is given about the relation between birth weight and sex, race, or socioeconomic status.

Using data from the Brown University sample of the Collaborative Project, Denhoff, Hainsworth, and Hainsworth (1972) related four indices of neurologic stress and outcome to school functioning at 7 years of age, including performance on the WRAT. Their predominantly white subjects were 380 children, two-thirds of whom were from unskilled blue-collar families.

All the index items were derived from Collaborative Study schedules. The Birth Stress Index included information on stress factors in maternal condition, pregnancy and birth complications, and newborn condition; the First Year Stress Index included items from the Birth Stress Index and stress items from a summary of first year development that included neurological, physical, and

social and environmental items. The Neonatal Outcome Index included information on neurological symptoms and defects in the newborn; the First Year Outcome Index included similar items from the neonatal period and the first year of life.

Low but significant correlations were found between WRAT performance and the First Year Stress Index ($r = -0.12$, $p = 0.05$, one-tailed), the Neonatal Outcome Index ($r = -0.21$, $p = 0.01$, one-tailed), and the First Year Outcome Index ($r = -.20$, $p = 0.001$, one-tailed). However, the correlation between the Birth Stress Index and WRAT performance was not significant.

The authors concluded that neurologic signs present at birth and during the first year of life are associated with poor learning skills and school performance at 7 years of age. Although their sample was mainly composed of low socioeconomic status families, they did not limit their conclusions to this group. They noted that most of their high-risk cases were from categories of "hyporeactivity" or "hyperreactivity."

The British National Child Development Study, another large-scale prospective study of an unselected sample of children, gathered data on the reading performance of 7-year-old children. Davie, Butler, and Goldstein (1972) discussed the performance on the Southgate Reading Test of approximately 13,958 British children, 90% of all those born in Britain from March 3 through 9, 1958.

Perinatal factors that were found to be significantly associated with reading test performance included maternal age

at pregnancy, maternal smoking during pregnancy, and birth weight. The authors expressed their findings in terms of the number of months gain in reading score that would result from progression along a continuum defined by each of these factors. Thus, an increase in maternal age from under 25 years of age to 25 to 30 years old would account for 4 months gain in reading age. A decrease in smoking from 10 cigarettes per day to none would account for a gain of 4 months. Similarly, a 1,000 g increment in birth weight would account for 4 months gain in reading age.

The Educational Follow-up Project (Balow, Anderson, Reynolds, & Rubin, Note 1) is engaged in following children from the Minnesota component of the Collaborative Project through their school years. From the total Minnesota sample of 1,613 children, a subsample of 241 subjects was drawn to determine the effects of birth weight and length of gestation on children's intelligence and achievement (Rubin, Rosenblatt, & Balow, 1973). The subjects were divided into four groups: low birth weight-preterm birth, low birth weight-full term birth, full birth weight-preterm birth, and full birth weight-full term birth.

Low birth weight was defined as no more than 2,500 g; gestation equal to or less than 37 weeks was considered preterm birth. There were no significant differences among the groups in socioeconomic level.

Significant differences favoring the high birth weight subjects were found on the Stanford-Binet (L-M, Short Form), administered at 4 years of age, on the Metropolitan Readiness Tests

and the Illinois Test of Psycholinguistic Ability administered at 5 years of age, and on the Wechsler Intelligence Scale for Children and the Wide Range Achievement Tests of reading, spelling, and arithmetic administered at 7 years of age. Neither gestational age nor sex of subject had any significant effect on these measures.

Three prospective studies failed to find a link between perinatal insult and reading disability. However, all of them have methodological problems serious enough to bring their findings into question.

Fraser and Wilks (1959) studied the long-term effects of neonatal asphyxia on 40 Scottish children who had been severely asphyxiated at birth and 60 who had been moderately asphyxiated. Most of the children were 7 1/2 years old when tested; some of the severely asphyxiated children were 10 1/2 or 11 1/2 years old. A control child was matched with each subject for sex and birth order, with good agreement on birth weight, social class, and mental age. The specific reading test used is not mentioned. There were no differences between survivors of neonatal asphyxia and their controls in reading skills.

Neonatal asphyxia was defined in this study in terms of the delay in onset of regular respiration and the first cry. Graham and her colleagues (Graham, Caldwell, Ernhart, Pennoyer, & Hartmann, 1957) suggested that measuring the condition of the infant immediately after birth is insufficient to identify those infants whose response to the anoxia is most severe. For their studies of

anoxic infants at 3 and 7 years old (Graham, Ernhart, Thurston, and Craft, 1962; Corah et al., 1965), anoxia was defined not only by clinical condition at birth, but also by signs of fetal anoxia occurring during the pregnancy and birth and signs of central nervous system disturbance occuring up to 3 days after birth. The more limited definition of asphyxia neonatorum used by Fraser and Wilks may not be sensitive enough to locate truly damaged children.

Robinson and Robinson (1965) compared the reading skills of three different groups of 8-through-11-year-old children, 25 of whom had weighed 1,500 g or less at birth, 99 weighing 1,501-2,500 g, and 90 weighing over 2,500 g at birth. There were no significant differences among the birth weight groups on the WRAT. However, although the groups were matched for race, sex, and paternal education, there were significant differences in maternal education and social class. Children from the lowest birth weight group tended to come from relatively disadvantaged homes, and children from the middle birth weight group from higher social class homes. Significant differences in reading scores due to social class differences were present; the confounding effect of these social class differences appears sufficient to negate the value of this report as a study of the effects of low birth weight.

Colligan (1970) used data from 386 children in the Minnesota sample of the Collaborative Project to investigate the correlation of perinatal experience with deficit in psychologic traits, including performance on the WRAT, at 7 years of age. He counted any and all deviations from "normal," ranging from minor to

serious, in the obstetric, delivery, and puerperium data from each child and recorded each deviation without any weighting. The sample was divided into three groups: "least stressed," "suspected stressed," and "presumed stress." The groups were not separated on any of the outcome variables.

These findings may be due to problems with the perinatal stress score and with the composition of the sample. In re-examining his data, Colligan found that the perinatal stress score did not increase systematically with evidence of neurologic impairment. Evidently too many items of little or no value were included, masking those items that are truly predictive of later deficiencies. Exclusions from the sample group included all subjects identified as abnormal or suspicious at the 7-year neurological examination, as well as children of mothers who had had fewer than five contacts with the obstetrician before delivery or whose records were incomplete.

Other Studies

Luong (1970) found no significant relation between the Apgar scores at birth and the performance on the WRAT at 7 years of age of 100 low socioeconomic status, black children from the Philadelphia component of the Collaborative Project. Her subjects, all of whom were full-term infants and had normal IQ's, appeared psychologically damaged in their performance on the 7-year test battery. They were compared with 100 control children, with the same ethnic and socioeconomic background, who did not show such difficulties.

Kruuse (1974) investigated the incidence of very low (no more than 2,500 g) and very high (no less than 4,500 g) birth weight among four groups of Danish school children: 115 reading class pupils, 93 mentally retarded pupils, 40 referred mentally deficient pupils, and 203 randomly selected normal pupils. When both weight extremes were combined, the first three groups all differed significantly from the normal group.

These two studies are discussed only briefly because their applicability is limited. Luong used a special group of subjects, and the evidence about the relation between her one perinatal variable, Apgar score, and long-term outcome is conflicting (Edwards, 1968; Shipe, Vandenberg, & Williams, 1968). Kruuse's complete study is available only in Danish so far, and detailed information about his subjects is not included in the English summary. It is questionable how comparable are Danish and American reading tasks, tests, and standards.

Some birth data is included in seven other studies of poor readers, which are interesting, but do not further this inquiry. Preston and Schneyer (1956) offered neurological data on nine severely retarded readers, four of whom had had abnormal or difficult births. Shimota (1956) included birth data in a study of the reading skills of a very special group, adolescents hospitalized for emotional disturbance.

Two studies reported on the incidence of atypical births in samples of children with reading problems, without comparing them with other groups. Tjossem, Hansen, and Ripley (1962) studied

24 children of normal intelligence who had serious difficulty in learning to read. Data on 364 children referred to a university remedial learning center over a 5-year period were offered by Coleman and Sandhu (1967).

Three studies include some birth data incidentally to their main topic. Eames (1959) noted that his sample of poor readers with endocrine disorder had a lower median birth weight than the control subjects. Warrington (1967) included data on birth injury in a report on the incidence of discrepancy in verbal and performance WISC IQ scores among children with reading and spelling backwardness. Black (1973) described the incidence of neurological, motor, behavioral, and perinatal abnormalities among poor readers with and without associated visual-perceptual dysfunction.

Summary

Within each group of studies, retrospective, retrospective follow-up, and prospective, more studies support than fail to support the hypothesis that perinatal stress is related to reading disability. The main points of each major study, grouped by research design and outcome, are summarized in Table 1. The points noted in the table include the independent variable, the dependent variable, and the outcome of each study.

A few points emerge clearly from these summaries: first, that prematurity by birth weight is the only perinatal variable that has been studied extensively, and second, that studies based on retrospective data appear to be more likely to have significant

results when they use data from medical records as well as parental memories. Although it may be an experimental artifact, three of the four retrospective studies failing to confirm the hypothesis used only information from parents, while only two of the seven retrospective studies confirming the hypothesis relied solely on parental recall.

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Insert Table 1 about here

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Methodological Concerns

The methodological problems of these studies of perinatal events and reading disability fall into three categories: control of variables, test use, and research design. All are interesting and worth discussing.

The problem of control of variables arises because in any comparison of two or more groups, variables that may be confounded with the independent variable or variables must be controlled, either by matching the subjects individually or by group or by after-the-fact statistical manipulation. Most studies controlled for some traits; however, approximately half neglected one or more important variables.

Malmquist and, possibly, Doehring and Black failed to control for social class of subjects. Malmquist, Jordan, Douglas, De Hirsch and her colleagues, and Kappelman and his colleagues did not control subjects' IQ. Malmquist did not control for sex.

Among the studies failing to show an association between perinatal insult and reading disability, Robinson and Robinson and, possibly, Richardson did not control for socioeconomic status; Lyle did not control for IQ. Versacci relied on random selection for control, while the control procedures of Menkes and his colleagues are unknown.

Failing to control for socioeconomic status may be more damaging to a study than failing to control for IQ. IQ is affected by perinatal events (see, e.g., Churchill, Neff, & Caldwell, 1956; Edwards, 1968; Harper, Fischer, & Rider, 1959; Werner, Bierman, & French, 1971); socioeconomic status is not. To control a nuisance variable which may be partially or totally determined by the independent variable is over-control (Burks & Kelley, 1928). However, because socioeconomic status has an independent effect on reading ability (Chandler, 1966) and on the incidence of perinatal problems (Pasamanick & Knobloch, 1958), comparison of outcomes within socioeconomic groups would be the preferred method.

Researchers in this area have employed a wide variety of tests, and thereby have, whether implicitly or explicity, used definitions of reading and IQ that varied widely. Moreover, the tests by which reading and IQ were defined were sometimes group- and sometimes individually-administered. Thus the tests used in different studies have varied on both content and process of administration, making the situation doubly-complicated. For example, in some studies reading was defined as oral word pronunciation. In others, tests of silent reading comprehension

were used. Definition of IQ varied from vocabulary only through group-administered IQ tests (which include a heavy component of reading skill) to individually-administered assessments of performance on non-verbal tasks.

As far as can be ascertained, only one author, Lyle, used a multi-variate technique of analysis. Most of the other researchers used either simple correlations and tests for significance or an inferential design testing group means. While multi-variate techniques necessitate large samples, they yield more information about the subjects than do less sophisticated methods. Increased use of such techniques would produce answers not only to the question of whether there is an association between perinatal problems and reading disability, but also to the question of the strength of any such association.

For The Future

It has been stated that the weight of the evidence supports the hypothesis that low birth weight and certain pregnancy and birth complications can impair later reading ability. Additional research in this area is unquestionably justified. However, for future work to add significantly to present knowledge, it must be carefully designed, comprehensive, and almost certainly must collect data in a prospective fashion so that the data can be considered to meet high standards of reliability and validity.

Elements of such careful design should include adequate procedures for control of variables and the use of sensitive methods of statistical analysis. More importantly, it may be

advisable to use not only specific perinatal problems as the independent variable under investigation but also an index of neonatal neurological damage, a factor whose association with later development seems reasonably well established.

It is most probable that some neurologic function or functions mediate between perinatal factors and later reading ability. If this is true, perinatal insults would have a long-term effect only to the extent that they damage neurologic functioning. To say that an infant is "anoxic" or "premature" or "born of a toxemic mother" is not assurance that he has suffered some neurologic impairment, although he may be at high risk for such impairment.

Two studies of reading disability offer support for adding an index of neurological damage to the variables analyzed. Denhoff, Hainsworth, and Hainsworth (1972) found that among the indices correlating significantly with functioning at age 7 were outcome indices derived from clinical summaries of neurologic symptoms and defects in the neonatal period and the first year of life. In the Lyle study (1970), symptoms of possible brain injury at birth correlated significantly with both factors that related to reading performance.

Prechtl and his collaborators (Prechtl & Dijkstra, 1959; Prechtl, 1965) have established a link between neonatal neurologic signs and behavior problems at age 2 to 4 years. Graham and her colleagues (Graham et al., 1957), in criticizing studies of the effects of perinatal anoxia, suggested the use of clinical ratings of neonatal condition as objective quantified measures of the

severity of anoxia, along with neonatal behavior tests measuring the degree of recovery from anoxia. Such methods could presumably be used in cases of other perinatal insults. The establishment of standardized neonatal examination and behavior test methods would allow increased comparison among the results of different researchers.

We are not suggesting that perinatal anomalies are unimportant. Far from it. Knowledge of such problems remains the first indicator of possible damage, and selected perinatal variables have been clearly tied to children's cognitive and affective behavior. However, clinical evaluation of the newborn does allow quantified estimates of the degree of damage in such children and, given sufficient development, could allow one to confirm or disconfirm causal chains extending from perinatal events to neurologic damage to, ultimately, reading and learning disability. Only then will we be able to locate confidently children at high risk for learning problems.

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Table 1

Findings of the Major Studies

Study	Independent Variable[a]	Dependent Variable[a]	Outcome
		Retrospective Studies - Confirming	
Kawi & Pasamanick, 1959	Reading at least 2 years below grade level	Pregnancy and birth information from hospital records	Poor readers are significantly more often premature and have significantly more pregnancy and birth complications in their histories than good readers.
Malmquist, 1958	Performance on 5 reading tests at least 1 standard deviation below the mean	Pregnancy and birth information from parents, maternity hospitals, and midwife records	Poor readers are significantly more often premature and have birth weights under 2,500 g significantly more often than good readers.
Versacci, 1966	Low reading achievement, defined by performance on the California Test of Mental Maturity and the Iowa Test of Basic Skills	Birth information from hospital records	Poor readers are significantly more often premature by gestation and birth weight and significantly more often have pregnancy complications in their histories than good readers, and their mothers have significantly more previous pregnancies and a significantly higher total number of complications than mothers of good readers.
Doehring, 1968	Performance on the WRAT[b] at least 2 years below age level	Birth information from parents	Poor readers tend to be premature more often and to have more short and long labors and lower birth weight than good readers.

Table 1 (Cont.)

Study	Independent Variable	Dependent Variable	Outcome
Galante et al., 1972	Reading below level expected from mental age	Birth information from parents, doctors, and birth hospital records	Poor readers have unusual birth histories significantly more often than good readers.
Black, 1972	Performance on the WRAT below grade placement	Birth information from an unknown source	Poor readers have significantly more birth abnormalities than good readers.
Kappelman et al., 1972	Referral to a remedial clinic	Birth information from parents	Clinic children have significantly more breech extraction, low birth weight, and pre-eclampsia in their histories than non-referred children.
	Retrospective Studies - Disconfirming		
Richardson, 1958	Performance on the Schonell Silent Reading Tests 18 months below age group	Birth information from parents	No difference in incidence of abnormal pregnancies or births between poor and good readers.
Lyle, 1970	Performance on the Schonell Graded Word Reading Test 2 years below control group	Birth information from parents	Brain injury at birth is significantly correlated with 2 factors of reading difficulty, and high birth weight with 1 of them. Neither factor is significantly correlated with toxemia of pregnancy, intrauterine complications, birth complications, or long or short labors.

Table 1 (Cont.)

Study	Independent Variable	Dependent Variable	Outcome
Hunter & Johnson, 1971	Referral to a remedial readirg clinic	Birth information from parents	No difference in birth weight or incidence of prematurity or breathing problems at birth between clinic and non-referred children.
Bakwin, 1973	History of reading disability	Birth information from an unknown source	No difference in birth weight between poor and good readers.
	Retrospective Follow-up Studies - Confirming		
Caplan et al., 1963	Prematurity	Performance on the Durrell Analysis of Reading Difficulty	Older prematures do significantly poorer than their controls. No difference between younger prematures and their controls.
Jordan, 1964	Pregnancy and birth complications	Performance on a number of academic achievement tests, including the Gates Basic Reading Tests and the Stroud-Hieronymous Reading Profiles	Children with histories of pregnancy and birth complications have learning and reading problems significantly more often than controls.
	Retrospective Follow-up Studies - Disconfirming		
Uddenberg, 1955	Prematurity	Performance on the Terman-Merrill Reading Test	No difference in the number of premature and control children failing to reach criterion.

Table 1 (Cont.)

Study	Independent Variable	Dependent Variable	Outcome
		Prospective Studies - Confirming	
Douglas, 1956	Prematurity	Performance on a reading test	Prematures' performance is significantly poorer than controls' performance.
Douglas, 1960	Prematurity	Performance on a reading test	Prematures' reading scores are significantly lower than controls' scores.
Corah et al., 1965	Anoxia	Performance on the Gilmore Oral Reading Test, Form A	Anoxics do somewhat less well than controls.
De Hirsch et al., 1966	Prematurity	Performance on the Gray Oral Reading Test and the Gates Primary Sentence and Paragraph Reading Tests (1st grade) and the Gates Advanced Primary Reading Tests (2nd grade)	At both levels, significantly more prematures than controls fail to reach critical score.
Wiener et al., 1956	Prematurity	Performance on the WRAT	Prematures' performance is significantly poorer than controls' performance.
Wiener, 1968	Prematurity	Reading/Grade (reading grade score divided by actual grade placement)	Birth weight and Reading/Grade are significantly correlated.

Table 1 (Cont.)

Study	Independent Variable	Dependent Variable	Outcome
Wiener, 1970	Birth weight and length of gestation	Performance on the WRAT	Among full-term children, those with longer gestations perform significantly better than others. There are no performance differences by gestation for low birth weight children.
Menkes et al., 1970	Birth weight	Performance on the WRAT	Low birth weight children tend to do poorer than high birth weight children.
Denhoff et al., 1972	Indices of birth stress, 1st-year developmental stress, and neonatal and 1st-year neurological symptoms and defects	Performance on the WRAT	Performance is correlated significantly with indices of first-year developmental stress and of neonatal and 1st-year neurological symptoms and defects.
Davie et al., 1972	Detailed pregnancy and birth information	Performance on the Southgate Group Reading Test	Poor readers weigh less at birth, have younger mothers, and have mothers who smoked more during pregnancy.
Rubin et al., 1973	Birth weight and length of gestation	Performance on the WRAT	Low birth weight subjects perform significantly poorer than controls. Length of gestation has no effect.

Table 1 (Cont.)

Study	Independent Variable	Dependent Variable	Outcome
		Prospective Studies - Disconfirming	
Fraser & Wilks, 1959	Neonatal asphyxia	Performance on a reading test	No difference in performance between asphyxiated subjects and controls.
Robinson & Robinson, 1965	Prematurity	Performance on the WRAT	No difference in performance between premature and full-term subjects.
Colligan, 1970	Early neurological abnormalities	Performance on the WRAT	Performance is not related to the number of neurological abnormalities.

[a]Although the independent and dependent variables in retrospective studies in this area are often considered to be the birth problem and reading performance, respectively, a moment's consideration of the way these studies are done--first identifying the good and poor readers and only then determining their histories--will make it clear why these items are ordered as they are in this table.

[b]Wide Range Achievement Test

Appendix A

Reading and Intelligence Tests Used in the Major Studies

Intelligence Tests

ACER (Australian Council of Educational Research) Junior Non-verbal Test

California Test of Mental Maturity

Kuhlmann-Anderson Intelligence Tests

Lorge-Thorndike Intelligence Tests

Otis Quick-Scoring Mental Abilities Test

Progressive Matrices

SRA Primary Mental Abilities

Stanford-Binet Scale

Terman-Merrill Intelligence Scale (a version of the Stanford-Binet Scale)

Wechsler Intelligence Scale for Children

Reading Tests

California Achievement Tests

Durrell Analysis of Reading Difficulty

Gates Advanced Primary Reading Tests

Gates Basic Reading Tests

Gates Primary Sentence Reading Test

Gates Paragraph Reading Test

Gilmore Oral Reading Test

Gray Oral Reading Tests

Iowa Tests of Basic Skills

Schonell Graded Word Reading Test

Appendix A (Cont.)

Schonell Silent Reading Tests

Southgate Group Reading Test

Stanford Achievement Test

Stroud-Hieronymous Primary Reading Profiles

Terman-Merrill Reading Test (one portion of the Terman-Merrill Intelligence Scale)

Wide Range Achievement Test

Some researchers used no tests, relying upon clinical referral to locate their reading-disabled subjects. Some designed their own, and some did not name the specific tests they used. A few used a multiplicity of tests. Some of these tests, notably the WISC and the WRAT, were used by more than one researcher.